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(71) Applicant(s)
Rover Group Limited
(Incorporated in the United Kingdom)
International Headquarters, Warwick Technology Park, WARWICK, CV34 6RG, United Kingdom

(72) Inventor(s)
Michael Neil Basnett
Martin Roy Haggett

(74) Agent and/or Address for Service
Alan S Wilson
Rover Group Limited, Gaydon Test Centre, Banbury Road, Lighthorne, Warwick, CV35 0RG, United Kingdom

(54) Abstract Title

Vehicle propulsion control in response to braking

(57) A vehicle 10 has an engine management system (EMS) 22 for controlling an engine 12 and a braking system 28 for slowing the vehicle 10 down. When the brake pedal 30 is applied, the EMS 22 restricts the engine torque output in a tuneable manner, regardless of any torque demand signal from the accelerator pedal demand potentiometer 26. The torque output is restricted progressively so as to permit a certain degree of left foot braking to assist, for example, in hill starts. Torque control may be by reducing fuel or air supply, or change of ignition timing. Alternatively, for electric vehicles, power to the motor is reduced. Torque output restriction itself may be limited or abandoned in response to a time delay, gear change or halting of the vehicle.

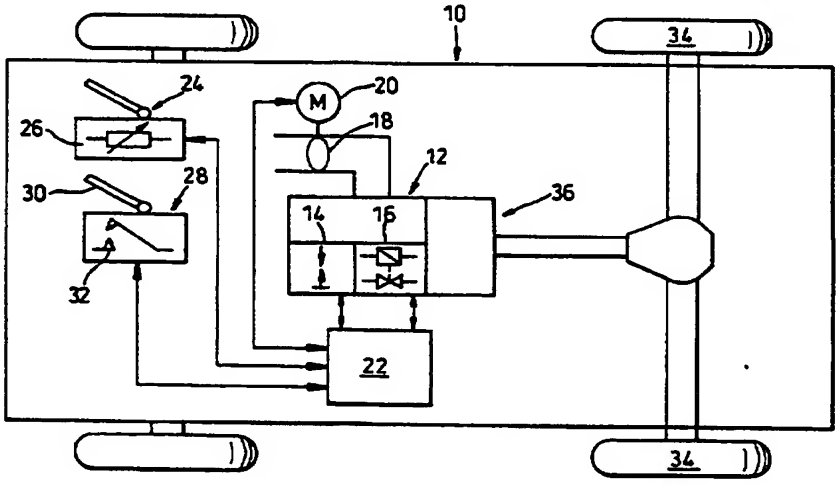

Fig. 1

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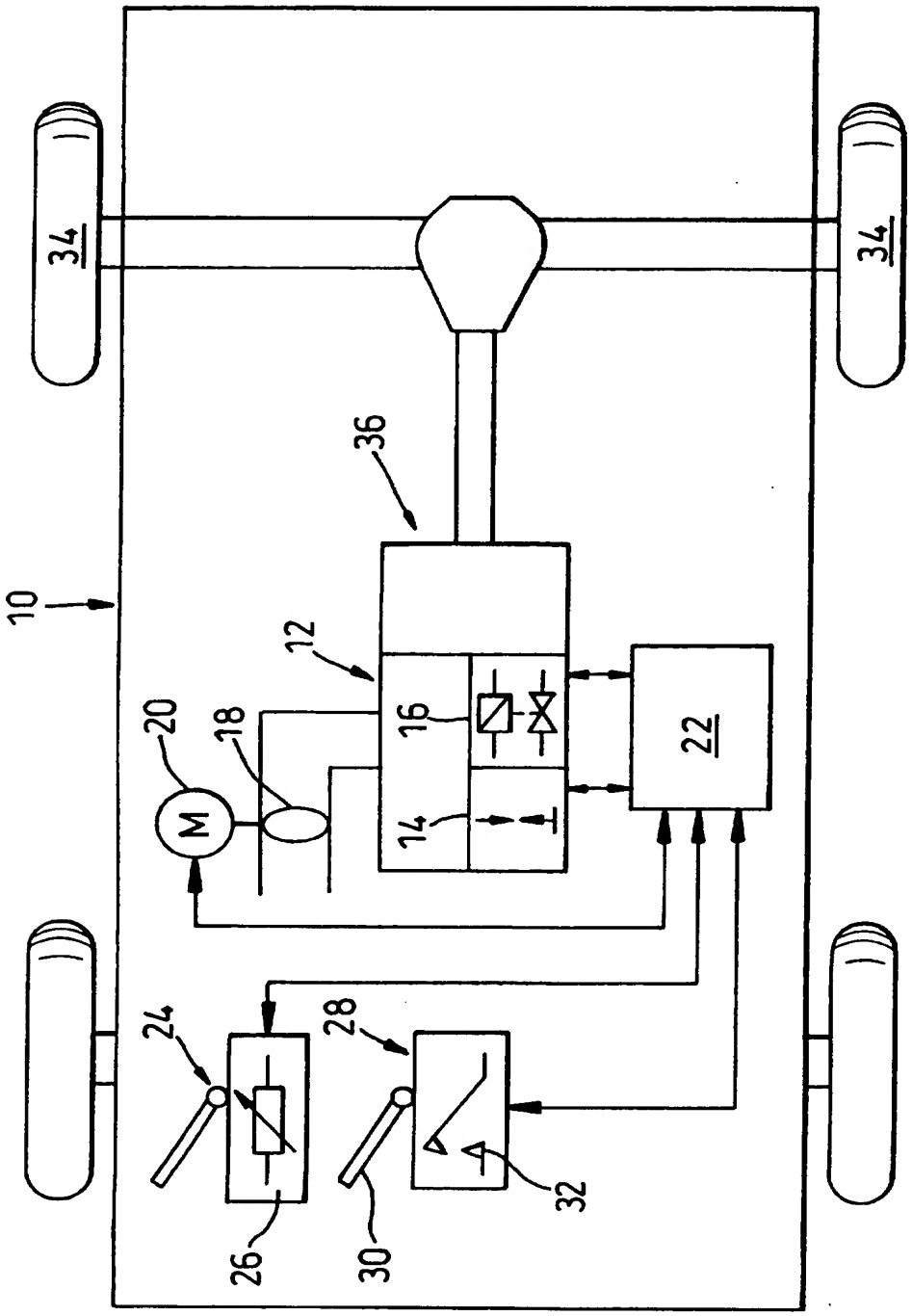

Fig. 1

A Control System for a Vehicle

This invention relates to control systems for vehicles and in particular to: a control system which controls the torque output of a prime mover of a vehicle; a control means for use in such a control system; a method of controlling such a control system; and to a vehicle including such a control system.

It is known to provide a vehicle with a prime mover, such as an engine, having a prime mover control system which controls the torque output of the prime mover. It is a known problem with some prior art systems for the torque output of the prime mover to remain at a high level even when a brake pedal is depressed. For example, such a case could arise if there were to be a fault in a pedal demand potentiometer forming part of an accelerator pedal of a drive-by-wire system, which might then indicate a continued acceleration demand signal even after the accelerator pedal had been released and the brake pedal had been depressed. A continued delivery of torque from the prime mover would act in opposition to the braking demand and reduce the efficiency of the vehicle braking system.

It is known from US 4,987,872 to provide a system which monitors accelerator and brake pedal positions and reduces the power output of the

engine by cutting off the air and / or fuel supply if the throttle sticks open or if the brake pedal is depressed at the same time as the throttle. This provides a rapid shut down of the system and ensures it fails safe with very little or no delay.

There are times, however, when it is desirable to have both the accelerator pedal and the brake pedal depressed simultaneously, for example during hill starts. A further example might arise if the driver were to be braking with the left foot and thereby might depress the accelerator pedal with his right foot and the brake pedal with his left foot at the same time. This technique is known in the art of driving, for example to rally drivers, as "left foot braking". The system of US 4,987,872 might interpret such hill starts or left foot braking as a fault condition and assume that the accelerator was stuck open. It would then reduce the torque, making such hill starts more difficult and such left foot braking less effective.

It is an object of this invention to provide: an improved control system which controls the torque output of a prime mover of a vehicle; a control means for use in such a control system; a method of controlling such a control system; and a vehicle including such a control system.

According to the invention there is provided a control system for a vehicle comprising a prime mover control means arranged in use to control

the output of torque from a prime mover in response to a torque demand signal from a torque demand means and a brake actuation means arranged in use to control the braking of the vehicle in response to a braking demand from a braking demand means, the prime mover control means being arranged to over-ride the torque demand signal and to restrict the torque output of the prime mover in response to the braking demand, wherein the prime mover control means is arranged to restrict the torque output by a progressive restriction with time in the supply of a power source to the prime mover after said braking demand.

The prime mover control means may be arranged to restrict the torque output for the duration of the braking demand and may be arranged to restrict the torque output to reach a projected idling torque output which provides the minimum torque output necessary to keep the prime mover running and to sustain any ancillary services supplied thereby.

The prime mover may comprise an engine and the prime mover control means may arranged to restrict the torque output by restricting the supply of fuel to a cylinder of the engine and alternatively or additionally by restricting the supply of air to a cylinder of the engine.

The prime mover may comprise a spark ignition engine and the prime mover control means may be arranged to restrict the torque output by altering the ignition timing of the engine.

The restriction of torque output may be programmably selected, reduced or deselected in use by a programming means.

The prime mover control means may be arranged to restrict the torque output only under one or more of the following conditions: after a predetermined time delay after the initiation of the braking demand; when the vehicle is stationary or travelling at a low speed; when a low transmission output ratio of the vehicle has been selected; or when a reverse transmission output ratio of the vehicle has been selected.

The invention also provides a vehicle having a control system according to the invention and a prime mover control means suitable for use in a control system according to the invention.

The invention also provides a method of controlling a control system for a vehicle comprising a prime mover control means arranged in use to control the output of torque from a prime mover in response to a torque demand signal from a torque demand means and a brake actuation means arranged in use to control the braking of the vehicle in response to a braking demand

from a braking demand means, the prime mover control means being arranged to over-ride the torque demand signal and to restrict the torque output of the prime mover in response to the braking demand, the method including the step of restricting the torque output by restricting progressively with time the supply of a power source to the prime mover after said braking demand.

The method may include restricting the torque output for the duration of the braking demand.

The method may include restricting the torque output to reach a projected idling torque output which provides the minimum torque output necessary to keep the prime mover running and to sustain any ancillary services supplied thereby.

The method may include:

a) calculating the prime mover idling settings necessary to achieve the projected idling torque output;

b) comparing said idling settings with the existing prime mover settings being applied when the braking demand signal is received;

c) calculating the changes to said existing settings necessary to achieve said idling settings within a predetermined period; and

d) varying the existing settings at a rate which achieves the idling settings substantially within said predetermined period.

The method may include varying the existing settings in steps.

The prime mover may comprise an engine and the method may include restricting the supply of fuel to a cylinder of the engine and alternatively or additionally by restricting the supply of air to a cylinder of the engine.

The prime mover may comprise a spark ignition engine and the method may include restricting the torque output by altering the ignition timing of the engine.

The method may include programmably selecting, reducing or deselecting the restriction of the torque output in use by using a programming means.

The method may include restricting the torque output only under one or more of the following conditions: after a predetermined time delay after the initiation of the braking demand; when the vehicle is stationary or travelling at a low speed; when a low transmission output ratio of the

vehicle has been selected; or when a reverse transmission output ratio of the vehicle has been selected.

The invention will now be described by way of example with reference to the accompanying drawing, in which:

Figure 1 is a schematic diagram of a vehicle having a control system according to the invention.

Referring to the figure, a vehicle 10 comprises a prime mover in the form of a spark ignition engine 12 having an ignition system 14 and a fuelling system comprising a fuel injection means 16 and a throttle butterfly 18 driven by a motor 20.

The vehicle 10 further comprises a prime mover control means in the form of an engine management system (EMS) 22 which controls the ignition system 14 and the fuelling system 16, 18, 20 to regulate the torque produced by the engine 12 which is used to drive a set of wheels 34 through a transmission 36.

The EMS 22 is connected to a drive-by-wire accelerator pedal 24 which acts as an engine torque demand means and includes a throttle demand potentiometer 26. The potentiometer 26 detects how far the accelerator

pedal 24 has been depressed and provides an electrical signal to the EMS 22 indicating how much torque is demanded, there being no mechanical connection between the accelerator pedal 24 and the engine 12.

The vehicle 10 further comprises a brake actuation means in the form of a hydraulic braking system 28 which is arranged to brake the wheels 34 in response to use of a brake pedal 30. The braking system 28 includes a conventional brake switch 32 which is connected to a pair of rear mounted brake lights (not shown) and also in parallel to the EMS 22. The brake switch 32 makes on use of the brake pedal 30 and provides power to the brake lights and at the same time also provides the EMS 22 with a braking demand signal which indicates operation of the brakes.

When the EMS 22 receives the braking demand signal, it over-rides any torque demand signal from the potentiometer 26 and reduces the torque produced by the engine 12 all the time that the braking demand signal is present.

The EMS 22 is programmed to reduce the torque progressively to the minimum output necessary to maintain an engine idle speed which can keep the engine 12 running and sustain the ancillary services supplied by it, such as an air conditioning system or a power steering system (not shown).

To reduce the torque progressively, the EMS 22 calculates the fuelling and ignition settings necessary to achieve the idle speed and compares the projected idle speed settings with the existing fuelling and ignition settings being applied when the braking demand signal is received. The EMS 22 then calculates the changes to the existing settings necessary to achieve the idle speed settings within a pre-determined and pre-programmed time t. The EMS 22 then reduces the torque in steps at a rate which will achieve the idle speed by the time t.

The torque output is reduced in this embodiment by using one or more of three techniques selected from a look-up table programmed in the EMS 22, the selection being made in a tuneable manner depending on the instant running conditions of the engine 12. The three methods of reducing torque are: by a stepped reduction of the quantity of fuel supplied to the cylinders of the engine 12 by the fuel injection system 16 on successive injection pulses; by the EMS 22 controlling the motor 20 to partially or fully close the throttle butterfly 18 and thereby to restrict the supply of air to the engine 12; and by controlling the ignition system 14 to retard the spark timing in steps on successive ignition pulses.

The initiation of the torque restriction is delayed for a short period after the braking demand signal is detected at the EMS 22, e.g. for one to two seconds, to allow for correct use of left foot braking during normal driving.

Such a situation might arise, for example, with a vehicle 10 having an automatic transmission 36 when the driver is performing a hill-start or when pulling away from stationary while towing, in either of which cases it may be useful to hold the vehicle 10 on the foot brake pedal 30 and to use the accelerator 24 to build up torque output before releasing the brake pedal 30.

The braking demand signal used by the EMS 22 to initiate the torque reduction may be derived directly from the brake switch 32 or may be supplied by the braking system 28. The only requirement is for the EMS 22 to detect when the driver wishes to brake the vehicle 10 in order that the EMS 22 may start reducing the engine torque.

This invention provides a reduction in engine torque to prevent a reduction in efficiency of the braking system 28 in retarding the vehicle 10, regardless of any signal from the pedal demand potentiometer 26 and thereby significantly reduces the likelihood of an unintentional acceleration of the vehicle 10, either through component failure of the torque demand means or through driver error.

The restriction of torque output is, however, performed progressively so that, for example, under conditions of left foot braking when towing, sufficient torque output can be maintained to perform hill starts. In one

example, the rate at which the torque output is restricted could be set such that the user could depress the accelerator pedal during a hill start so as to increase torque output at a greater rate than it was being restricted. In this manner, the user chooses to counter act or overcome the torque restriction and build up enough torque to pull away on releasing the brake, at which point the torque restriction would be abandoned anyway releasing full power for the pull uphill. Under these circumstances, the system still fails safe as the rate at which the torque is restricted can be programmed to increase rapidly after a preset delay of, say, 5 seconds. There is also the in-built limitation of accelerator travel, as the accelerator travel will reach its full scale deflection and the torque restriction will catch it up, overtake it and thereby fail safe unless the brake pedal is released before the torque restriction overtakes the accelerator pedal.

In a modification to this invention, the EMS 22 is arranged to give the driver the option to selectively disable or limit the torque restriction feature for any or all of the situations when torque restriction might be employed. This situation arises, for example, when the vehicle 10 is being used in motorsport competition and the driver may actively want to use left foot braking. The disabling or limiting of the torque restriction is controlled by an "enable restriction / reduce level of restriction / disable restriction" instruction which is only accessible using a diagnostic aid programmed with a specific software routine and the instruction is provided to the EMS 22 for

implementation. The instruction is logged in the EMS 22 and its status is retrievable using the diagnostic aid, for example, in the event of any dispute over when or whether the feature had been disabled or reduced in effect, before an accident which might otherwise have been avoided had the torque restriction been operating fully. For safety reasons, a default setting is provided by which the torque restriction feature is enabled and the driver must make a conscious and deliberate decision to disable the feature.

This invention is not restricted to vehicles having an internal combustion engine 12 as a prime mover and could equally be applied to another type of prime mover, such as an electric traction motor. The torque restriction feature would, in that case, reduce the power supply to the motor to reduce torque and might additionally, or in the alternative, use regenerative braking to reduce the driving torque to the wheels while a brake demand signal were present.

CLAIMS

1. A control system for a vehicle comprising a prime mover control means arranged in use to control the output of torque from a prime mover in response to a torque demand signal from a torque demand means and a brake actuation means arranged in use to control the braking of the vehicle in response to a braking demand from a braking demand means, the prime mover control means being arranged to over-ride the torque demand signal and to restrict the torque output of the prime mover in response to the braking demand, wherein the prime mover control means is arranged to restrict the torque output by a progressive restriction with time in the supply of a power source to the prime mover after said braking demand.

2. A control system according to Claim 1, wherein the prime mover control means is arranged to restrict the torque output for the duration of the braking demand.

3. A control system according to Claim 1 or Claim 2, wherein the prime mover control means is arranged to restrict the torque output to reach a projected idling torque output which provides the minimum torque output necessary to keep the prime mover running and to sustain any ancillary services supplied thereby.

4. A control system according to any preceding claim, wherein the prime mover comprises an engine and the prime mover control means is arranged to restrict the torque output by restricting the supply of fuel to a cylinder of the engine.

5. A control system according to any preceding claim, wherein the prime mover comprises an engine and the prime mover control means is arranged to restrict the torque output by restricting the supply of air to a cylinder of the engine.

6. A control system according to any preceding claim, wherein the prime mover comprises a spark ignition engine and the prime mover control means is arranged to restrict the torque output by altering the ignition timing of the engine.

7. A control system according to any preceding claim, wherein the restriction of torque output is programmably selected, reduced or deselected in use by a programming means.

8. A control system according to any preceding claim, wherein the prime mover control means is arranged to restrict the torque output only after a predetermined time delay after the initiation of the braking demand.

9. A control system according to any preceding claim, wherein the prime mover control means is arranged to restrict the torque output only when the vehicle is stationary or travelling at a low speed.

10. A control system according to any preceding claim, wherein the prime mover control means is arranged to restrict the torque output only when a low transmission output ratio of the vehicle has been selected.

11. A control system according to any preceding claim, wherein the prime mover control means is arranged to restrict the torque output only when a reverse transmission output ratio of the vehicle has been selected.

12. A control system substantially as described herein with reference to the accompanying drawing.

13. A vehicle having a control system according to any preceding claim.

14. A prime mover control means suitable for use in a control system according to any one of claims 1 to 12.

15. A method of controlling a control system for a vehicle comprising a prime mover control means arranged in use to control the output of

torque from a prime mover in response to a torque demand signal from a torque demand means and a brake actuation means arranged in use to control the braking of the vehicle in response to a braking demand from a braking demand means, the prime mover control means being arranged to over-ride the torque demand signal and to restrict the torque output of the prime mover in response to the braking demand, the method including the step of restricting the torque output by restricting progressively with time the supply of a power source to the prime mover after said braking demand.

16. A method according to Claim 15 including restricting the torque output for the duration of the braking demand.

17. A method according to Claim 15 or Claim 16, including restricting the torque output to reach a projected idling torque output which provides the minimum torque output necessary to keep the prime mover running and to sustain any ancillary services supplied thereby.

18. A method according to claim 17 including:

a) calculating the prime mover idling settings necessary to achieve the projected idling torque output;

b) comparing said idling settings with the existing prime mover settings being applied when the braking demand signal is received;

c) calculating the changes to said existing settings necessary to achieve said idling settings within a predetermined period; and

d) varying the existing settings at a rate which achieves the idling settings substantially within said predetermined period.

19. A method according to Claim 18 including varying the existing settings in steps.

20. A method according to any one of Claims 15 to 19, the prime mover comprising an engine and including restricting the torque output by restricting the supply of fuel to a cylinder of the engine.

21. A method according to any one of Claims 15 to 20, the prime mover comprising an engine and including restricting the torque output by restricting the supply of air to a cylinder of the engine.

22. A method according to any one of Claims 15 to 21, the prime mover comprising a spark ignition engine and including restricting the torque output by altering the ignition timing of the engine.

23. A method according to any one of Claims 15 to 22, including programmably selecting, reducing or deselecting the restriction of the torque output in use by using a programming means.

24. A method according to any one of Claims 15 to 23, including restricting the torque output only after a predetermined time delay after the initiation of the braking demand.

25. A method according to any one of Claims 15 to 24, including restricting the torque output only when a low transmission output ratio of the vehicle has been selected.

26. A method according to any one of Claims 15 to 25, including restricting the torque output only when the vehicle is stationary or travelling at a low speed.

27. A method according to any one of Claims 15 to 24, including restricting the torque output only when a reverse transmission output ratio of the vehicle has been selected.

28. A method substantially as described herein with reference to the accompanying drawing.

The Patent Office

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Application No: GB 9808378.5 **Examiner:** Michael Prescott
Claims searched: 1-28 **Date of search:** 15 July 1998

Patents Act 1977
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Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.P): G3N (NGA2, NGA4, NGD, NGDB, NGE1, NGE1A, NGE1B)

Int Cl (Ed.6): B60K 41/00, 41/20, 41/28; B60L 3/00, 3/06, 15/10

Other: Online: WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	WO95/34441 A1	(Westinghouse Electric Corporation) see claim 1.	14
X	US 5139121	(Kubota Corporation) see in particular column 3 lines 39 to 49 and line 63 to column 4 line 4	1, 2, 7, 13-16, 23

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

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Özlem Türköz
DaimlerChrysler AG
Research and Technology
Intellectual Property Management
096/C106 - IPM/C
70546 Stuttgart

Phone +49-(0)7 031-6288-345
Fax +49-(0)7 031-6288-581
mailto: oezlem.tuerkoez@daimlerchrysler.com

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